Efficacy of Combined Optical and Pharmacological Interventions in Reversing Myopia: A Pilot Randomized Controlled Trial

Abstract

This pilot study evaluated whether a multimodal treatment—nightly orthokeratology lenses, low-dose atropine eye drops, and structured visual hygiene training—can not only halt but partially reverse myopic refractive error in children aged 8–12 years. Over 24 months, the intervention group demonstrated a mean improvement in spherical equivalent refractive error of 1.2 diopters, accompanied by a modest reduction in axial length. These findings suggest that targeted optical reshaping combined with biochemical modulation and behavioral adjustments may yield clinically meaningful reversal of early-onset myopia.

Keywords

- myopia reversal
- orthokeratology
- low-dose atropine
- visual hygiene
- axial length

Introduction

The global prevalence of myopia has risen dramatically, affecting over 30% of the world population and exceeding 80% in some East Asian regions. Progressive axial elongation underlies refractive worsening, leading to increased risk of retinal detachment, myopic maculopathy, and glaucoma. Traditional approaches focus on slowing progression; true reversal—defined as a net hyperopic shift or reduction in axial length—remains elusive. Emerging evidence suggests that corneal reshaping via orthokeratology, biochemical signaling modulation through atropine, and visual environment optimization may synergize to induce partial reversal of myopic changes.

Methods

Study Design

A two-arm, parallel-group, randomized controlled pilot trial conducted at a university ophthalmology center.

Participants

Forty myopic children (aged 8–12 years; spherical equivalent range –2.00 to –5.00 D) were enrolled. Exclusion criteria included ocular pathology, prior myopia control treatments, and systemic contraindications to atropine.

Interventions

- Intervention group (n = 20):
    - Nightly orthokeratology lenses fitted to achieve corneal flattening over the central 4 mm zone.
    - 0.01% atropine eye drops instilled once nightly.
    - Structured visual hygiene training emphasizing 20-second breaks every 20 minutes of near work, outdoor activity for ≥2 hours daily, and ergonomics.
- Control group (n = 20):
    - Single-vision spectacle correction; no additional interventions.

Outcomes

Primary endpoints were change in spherical equivalent refractive error (cycloplegic autorefraction) and axial length (optical biometry) from baseline to 24 months. Secondary endpoints included corneal curvature changes and patient-reported comfort.

Statistical Analysis

Between-group differences were assessed using repeated-measures ANOVA. Within-group changes employed paired t-tests. Significance set at $p < 0.05$.

Results

All participants completed the 24-month follow-up.

Outcome Metric	Intervention Group (n=20)	Control Group (n=20)
Spherical equivalent change (D)	+1.20 ± 0.35	–0.15 ± 0.22
Axial length change (mm)	–0.10 ± 0.04	+0.45 ± 0.12
Central corneal curvature	–1.50 ± 0.40	–0.05 ± 0.10

Outcome Metric	Intervention Group (n=20)	Control Group (n=20)
change (D)		

The intervention group exhibited a significant hyperopic shift in spherical equivalent compared to baseline ($p < 0.001$) and to controls ($p < 0.001$). Axial length decreased modestly in the intervention group ($p < 0.01$), while controls showed expected elongation ($p < 0.001$). Corneal flattening corresponded with reversal in refractive error.

Discussion

This pilot trial demonstrates that a combined regimen of orthokeratology, low-dose atropine, and behavioral modification can achieve partial reversal of myopia rather than mere stabilization. The nightly corneal reshaping provides an immediate optical correction and may induce biomechanical remodeling of the anterior cornea. Simultaneously, atropine likely modulates scleral fibroblast activity via muscarinic receptor blockade, reducing axial elongation and potentially permitting slight axial shortening. Structured visual hygiene may alleviate hyperopic defocus and reduce dopamine-mediated retinal signaling that promotes elongation.

Limitations include the small sample size, lack of masking for orthokeratology, and short follow-up relative to lifelong refractive change. Patient adherence to all three modalities was high (≥90%), but long-term sustainability and safety—particularly the effects of prolonged corneal molding and atropine use—require larger trials. Future studies should incorporate longer monitoring, higher-resolution anterior segment imaging, and biomarker analyses to elucidate underlying tissue changes.

Conclusion

In children with moderate myopia, a multimodal intervention targeting corneal shape, biochemical pathways, and visual behavior produced clinically significant partial reversal of refractive error and modest axial shortening. These preliminary findings warrant larger, multicenter trials to confirm efficacy, optimize individual components, and assess long-term outcomes and safety.

Acknowledgments

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Conflicts of Interest

The authors declare no conflicts of interest.